SOME LIVE OAK FORESTS OF NORTHEASTERN FLORIDA

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Introduction

The ecology of live oak (*Quercus virginiana* Mill.) in Florida poses many interesting and perplexing problems. In northeastern Florida live oak forests form a small but important and conspicuous vegetation type. Such forests may be found inland as well as in coastal regions. On the inland areas live oak stands may be encountered on sandhill sites, on better drained portions of the pine flatwoods areas, as a seral stage following scrub, or fringing lakes, streams, and sinkholes (Davis 1961). Live oak stands, under these circumstances plus an occasional fire, coupled with the longevity of the species, may persist for an extended period of time. This leads to the problem of establishing the ecological position of live oak in the successional and climax vegetation in northeastern Florida.

The purposes of this study were two-fold: (1) to determine whether the coastal live oak hammocks represent a salt spray climax as in North Carolina, and (2) to determine the position of live oak in succession in the inland sites, particularly the drier portion of the pine flatwoods.

Methods

The live oak hammocks considered in this study are located in north central Florida between Gainesville, St. Augustine, and Flagler Beach. All the hammocks investigated have been free of fire for at least 15 years or more. Evidence of some selective cutting of pine was observed in a few cases. Grazing in the inland stands may have occurred within the past 20 years, though the effects of this are not obvious.

During the summer of 1959 eight live oak hammocks, representing three general site classifications, were sampled. Four of the eight stands occupied scrubby flatwood areas (slightly higher and drier portions of the pine flatwoods). These four, when classified on the basis of the maturity of the live oak, are treated as fol-

lows: 1 incipient live oak hammock, 1 intermediate, and 2 mature. One of the eight stands was an intermediate live oak hammock located on a sandhill site. Of the three remaining, two are located on old offshore bars and one on an old sand dune within one half mile of the coast. These three latter hammocks are mature and they are close enough to the ocean for the canopy to exhibit a pronounced shearing effect of wind and salt spray.

All of the stands studied are significantly located in that they are in areas where natural fire barriers exist in the form of bodies of water or artificial barriers such as roads, cultivated land, and protected parks and reserves.

Basal area for stems 1 inch dbh in seven stands was recorded in 10 alternate 10 meter square quadrats. In seven stands this was done by sampling 5 alternate quadrats in two parallel 100 meter lines separated by at least 10 meters. Total shrub and herb cover was estimated in one 16 meter square quadrat in a fixed corner of the larger quadrat. The species within were listed in order of abundance. The relative abundance of seedings and sprouts of trees was recorded but not counted due to the high frequency of sprout occurrence, especially in live oak. The eighth stand, a coastal live oak hammock, was sampled by the transect method. A transect 120 x 20 meters, perpendicular with the coast, was established and each contiguous 10 x 20 meter segment was sampled for basal area. A presence list was compiled for all stands.

Results

SCRUBBY FLATWOODS SITE

(1) *Incipient Live Oak Hammock*

The incipient live oak hammock is located in the University of Florida Conservation Reserve at Welaka. The area has been protected from fire for 20 years.

Live oak is clearly the dominant species in the incipient hammock (Table 1). This stand has a discontinuous canopy of live oak about 15-20 feet in height with an occasional large, towering slash pine (*Pinus ellottii* Engelm.). Live oak averaged 2.9 inches dbh with the larger specimens slightly over 7 inches. Slash pine averaged 15.5 inches dbh.

Below the low live oak canopy and above the lower shrub layer, but merging into both, staggerbush (*Lyonia ferruginea* Nutt.)

and Chapman's oak (*Quercus chapmanii* Sarg.) form a tangled growth.

The shrub layer is dense (53% cover) and consists primarily of saw palmetto (*Serenoa repens* (Bartr.) Small), fetterbush (*Lyonia lucida* (Lam.) K. Koch), and smaller individuals of live oak, staggerbush, and Chapman's oak. Scattered through the shrub layer are a few small laurel oak (*Quercus laurifolia* Michx.) seedlings ($<$ 1 ft. in height) and saplings ($>$ 1 ft. in height and $<$ 1 inch dbh). The vine *Galactia elliottii* Nutt. is frequent.

The herb layer is sparse. The principal herbs are wiregrass (*Aristida stricta* Michx.), *Panicum patentifolium* Nash, and *Rhynchospora dodecandra*.

(2) *Intermediate Live Oak Hammock*

This hammock is located 1.5 miles southwest of San Mateo on U. S. 17. The stand studied is between the highway and the St. Johns River. Between the hammock and river there is a mesic hammock. Scrubby flatwoods lie between the road and the intermediate hammock.

The canopy in this hammock is about 40 feet in height and more continuous than in the incipient hammock. Live oak is again the dominant tree (Table 1) though there was a slight decrease in trees per acre. The live oak averaged 3.8 inches with the larger trees being over 18 inches dbh. The abundance of staggerbush had decreased whereas Chapman's oak remained the same. Myrtle oak (*Quercus myrtifolia* Willd.) showed an increase in trees per acre. This increase is probably associated with the choice of site rather than with successional trends.

One of the most noticeable differences between the incipient and intermediate live oak hammocks is the increase in laurel oak from a few seedlings and saplings in the former to 352 trees per acre in the latter which averaged 1.6 inches dbh. The largest laurel oak measured was 2.8 inches. The appearance of small individuals of hickory (*Carya glabra* (Mill.) Sweet), American holly (*Ilex opaca* Ait.), and wild olive (*Osmanthus americanus* (L.) Gray) suggests a successional trend. Scattered through this stand are occasional large magnolia (*Magnolia grandiflora* L.) though only seedlings and saplings of this species are encountered in the sample area.

TABLE 1

PERCENT BASAL AREA AND TREES PER ACRE FOR LIVE OAK FORESTS LOCATED ON THREE DIFFERENT SITE CONDITIONS. UNDER EACH SITE CONDITION THE STANDS HAVE BEEN CLASSIFIED ON THE BASIS OF MATURITY. T EQUALS LESS THAN 0.1 PERCENT.

Species	Scrubby Flatwoods						Sandhill		Coastal	
	Incipient		Intermediate		Mature		Intermediate		Mature	
	% B.A.	Trees /A	% B.A.	Trees /A	% B.A.	Trees /A	% B.A.	Trees /A	% B.A.	Trees /A
Quercus virginiana	69.0	560	89.0	496	81.7	66	91.5	368	57.3	66
Pinus elliottii	21.2	8	—	—	1.4	4	—	—	—	—
Lyonia ferruginea	7.5	296	1.0	144	0.3	2	—	—	—	—
Quercus chapmanii	2.2	104	3.0	104	T	2	—	—	—	—
Quercus myrtifolia	0.2	16	0.4	32	0.9	88*	—	—	—	—
Quercus laurifolia	—	—	6.0	352	3.6	88	8.5	744	9.8	68
Carya glabra	—	—	0.3	24	—	—	—	—	4.8	37
Ilex opaca	—	—	0.2	24	6.1	110	—	—	0.1	8
Osmanthus americanus	—	—	0.2	32	—	—	—	—	0.5	19
Vaccinium arboreum	—	—	0.1	16	0.7	16	—	—	—	—
Quercus nigra	—	—	—	—	2.3	16	—	—	—	—
Nyssa biflora	—	—	—	—	1.1	4	—	—	—	—
Liquidambar styraciflua	—	—	—	—	0.9	2	—	—	—	—
Sabal palmetto	—	—	—	—	0.7	2	—	—	17.7	53
Myrica cerifera	—	—	—	—	0.1	16	—	—	—	—
Magnolia grandiflora	—	—	—	—	—	—	—	—	7.9	59
Persea borbonia	—	—	—	—	—	—	—	—	1.6	47
Ilex vomitoria	—	—	—	—	—	—	—	—	0.4	72
Iuniperus silicoicola	—	—	—	—	—	—	—	—	0.1	3
	49.5 sq. ft. per A.	984	88.5 sq. ft. per A.	1224	127.3 sq. ft. per A.	416	95.2 sq. ft. per A.	1112	184.8 sq. ft. per A.	432

The shrub layer is 5-6 feet in height and was dense (67% cover). The important species present are the same as those in the younger hammock. Laurel oak saplings are more important. Saplings of wind olive, hickory, American holly, and magnolia are indicative of trend toward climax species. The herb layer is practically absent.

(3) *Mature Live Oak Hammock*

Two mature live oak hammocks were studied. One is 2.2 miles southwest of Rochelle. This stand is protected from fire on the west by a small stream and adjoining swamp, on the north by a state highway, on the east by a sand road, and on the south by a small rural settlement. The second stand is located in the Welaka Reserve where it has been protected from fire and grazing for 20 years.[1]

The live oak in the mature hammocks form an almost continuous canopy about 75 feet in height. The number of live oaks per acre has decreased from around 500 in the two younger to 66 in the mature hammock. The live oaks averaged 15.5 inches dbh with the range being 4.5 to 32.5 inches dbh. Most of these had huge crowns frequently formed from numerous branches which originate from the main trunk about 8-10 feet from the ground or from several trunks connected to a common root system. Most of these trees had fire scars on the trunks near the ground.

American holly, a tree common in the climax mesic hammocks in north central Florida, is the second most important tree. The 110 trees per acre for this species averaged 3.1 inches dbh with the larger specimens being over 10 inches dbh. Frequently several small trees of American holly originate from a common root system. This undoubtedly resulted from past fire damage.

Laurel oak exhibits an increase in average diameter from 1.6 inches in the intermediate hammock to 3.0 inches in the mature hammock. The larger laurel oaks are over 6 inches dbh.

The decrease in staggerbush and Chapman's oak and the appearance of water oak (*Quercus nigra* L.) seems significant. The appearance of cabbage palm (*Sabal palmetto* (Walt.) Lodd.) and the other species listed for the mature hammock in Table 1 are not considered a significant successional trend.

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[1] A portion of this hammock was studied previously by Laessle (1942 and 1958a).

The understory in the mature hammock is irregular in height and discontinuous. The principal components are American holly and laurel oak transgressives.

Reproduction of live oak is largely by root sprouts. Laurel oak, magnolia, and redbay (*Persea borbonia* (L.) Spreng.) are represented by seedlings and saplings as well as by sprouts. It is noteworthy that seedlings and saplings of live oak were not found. Small sprouts of this species were seen but it appeared that they would never form trees. The ability of live oaks to form thickets from root sprouts has been reported by Laessle (1958a).

The shrub layer is variable in height as well as percent of cover. The average cover is 50% though the two extremes occurred at times in different quadrats. Sprouts and saplings of laurel oak, magnolia, and myrtle oak are important tree species. Important shrubs and vines are grape (mostly *Vitis rotundifolia* Michx.), yellow jessamine (*Gelsemium sempervirens* (L.) Ait.), cross vine (*Bignonia capreolata* L.), saw palmetto, *Vaccinium caesium* Greene, smilax (mostly *Smilax laurifolia* L. and *S. bona-nox* L.), and *Galactia elliottii* Nutt.

The herb layer is poorly represented. *Mitchella repens* L. and *Elephantopus nudatus* Gray are the more frequent components.

SANDHILL SITE

(1) *Intermediate Live Oak Hammock*

This stand is located 2.8 miles east of Welaka on the Pomona road. It is nearly surrounded by orange groves.

Live oak forms a continuous canopy about 40 feet in height. The live oaks averaged 6.4 inches dbh with the range being 3.3 to 9.7 inches. No seedlings and only an occasional sprout were observed.

The remnants of the longleaf pine-turkey oak (sandhill) community are present in the form of fire charred and partially decayed pine stumps and an occasional turkey oak.

The understory is about 15 feet in height and it was nearly continuous. The 744 laurel oaks are its only component (Table 1). They are all below 2.5 inches dbh with the average being 1.3 inches.

The shrub layer in this site has only half as much cover (30%) as in the intermediate hammock on the scrubby flatwoods area. Laurel oak is the principal component.

Other than a few turkey oak and longleaf pine stumps several other plants present suggest that this was formerly a sandhill community. These are (*Asimina angustifolia* A. Gray, *A. obovata* (Willd.) Nash, *Asclepias tuberosa* L., *Phoebanthus tenuifolia* (T. and G.) Blake, *Tragia urens* L., *Tephrosia chrysophylla* Pursh., *Croton argyranthemus* Michx., *Carphephorus cormybosus* (Nutt.) T. and G., *Psoralea canescens* Michx., and *Aristida* spp.). Most of these species are represented only by a few spindley specimens that showed no indication of flowering or fruiting.

COASTAL SITE

(1) *Mature Live Oak Hammock*

The three coastal live oak hammocks are located along U. S. highway A1A between St. Augustine and Flagler Beach. One is located in Anastasia Island State Park. The other two are east of A1A.

Each of the live oak hammocks investigated on the coastal site is about a half a mile from the ocean, and they are the first forests encountered behind the foredunes. Between the dunes and the forests are low thickets or brackish marshes. The canopy in each of the hammocks studied gradually sloped eastward until it merged into the thicket behind the foredunes. The slope of the canopy showed every characteristic of being the result of wind and salt spray.

The relative abundance and basal area of the tree species in these stands is shown in Table 1. Live oak was represented by 66 trees per acre which averaged 11.4 inches dbh. The size ranged from 10.1 inches dbh to 35.6 inches dbh in one of the stands while the others ranged from 4.2 to 17.3 and 6.1 to 25.2 inches dbh. Cabbage palm ranked second, though this species was encountered only in the sample in the non-dune stands.

Laurel oak is third in basal area. The 68 trees per acre average 5.8 inches dbh while the larger specimens are 13 inches dbh. The fourth species is magnolia with an average 53 trees per acre, and an average dbh of 4.9 inches though the largest individual was 17.2 inches. This specimen was within 20 meters of the low thicket and its crown had been trained by wind and salt spray. Pignut hickory is fifth with 4.5 percent basal area. The largest specimen

seen was 24.6 inches dbh and it too was within 20 meters of the low thicket.

Redbay, though not contributing much basal area, is represented by 47 trees per acre with the larger ones being slightly over 10 inches dbh.

The understory varies in height and continuity. Yaupon (*Ilex vomitoria* Ait.), laurel oak, pignut hickory, magnolia, redbay, American holly, and wild olive are the principal components.

The cover of the shrub layer is 53 percent. Saw palmetto, yaupon, grape, and the sprouts and saplings of the tree species are the main members.

Elephantopus nudatus Gray, *Scleria triglomerata* Michx., and *Panicum commutatum* Schultes are the important herbs.

Most of the data obtained from the 120 x 20 meter transect, which runs perpendicular to the coast but about a half a mile inland, are given in Figure 1. This transect was so placed that it would extend from the "live oak-mesic hammock" eastward into the low scrub forest. The canopy at the western end of the transect is about 75 feet in height while the canopy at the eastern extreme is about 20 feet in height. There is a gradual decrease in canopy height from west to east. Total basal area also decreases from west to east. This is related to a decrease in average dbh rather than in trees per acre. The latter actually increases from west to east. It should be pointed out that the only significant abrupt decrease in total basal area comes at the point where the scrub trees (Chapman's oak, myrtle oak, and staggerbush) begin to appear.

The basal area of species along this transect is clearly shown in Figure 1. Many of the important tree species common in the inland climax mesic hammocks (laurel oak, magnolia, redbay, pignut hickory, and wild olive) are present throughout the transect even though they are represented only by seedlings, saplings, or sprouts in the scrub forest. Live oak, though present throughout, is over 6 inches dbh only in the western end of the transect where the other species mentioned above had larger trees as well as reproductive classes there. Another important feature is the presence of dead trees of Chapman's oak west of where the live ones presently occur.

The distribution of some of the subordinate species is shown in Figure 1. For the most part the occurrence of these species ap-

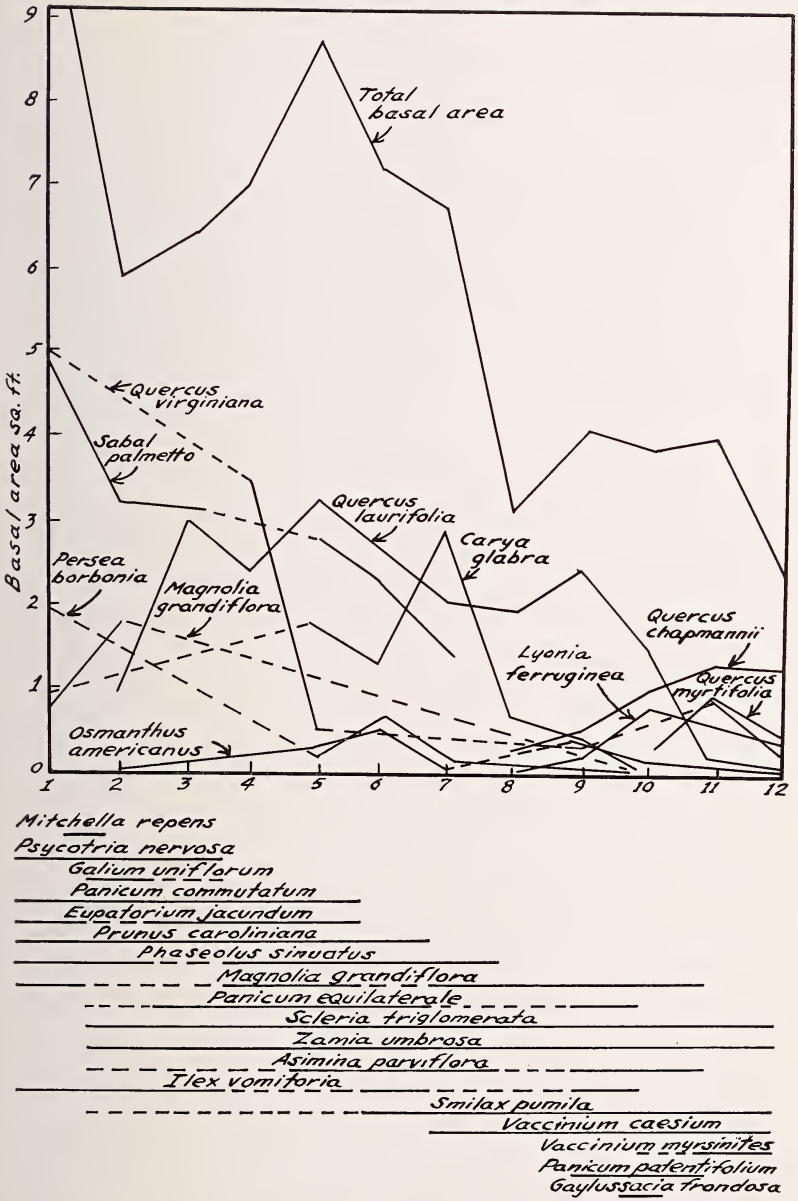

Figure 1. Graph of the principal species according to basal area along a 20 x 120 m. transect. Horizontal intervals 10 meters. The lower portion of this figure indicates the range of herbaceous and small, woody species in the same intervals of the transect. The broken lines designate non-contiguous occurrence of the species in the 10 meter intervals.

pears to follow the development of the forest from the scrub forest to the mesic hammock.

TABLE 2

FREQUENCY AND PRESENCE OF SPECIES WHICH OCCURRED IN HALF OR MORE OF THE EIGHT STANDS STUDIED.

Species	Frequency 70 Quadrats	Presence 8 Stands	Presence* 17 Stands
TREES			
Quercus virginiana	89	100	100
Quercus laurifolia	81	100	—
Magnolia grandiflora	30	62	—
Persea borbonia	27	62	82
Ilex opaca	24	62	65
Sabal palmetto	18	62	35
Osmanthus americanus	14	62	82
Quercus myrtifolia	27	50	—
Lyonia ferrugenia	26	50	—
Carya glabra	24	50	—
Diospyros virginiana	7	50	—
SHRUBS AND VINES			
Smilax spp.	67	100	100
Serenoa repens	48	100	—
Vitis spp.	67	87	100
Callicarpa americana	16	87	71
Parthenocissus quinquefolia	23	62	65
HERBS			
Panicum spp.	47	100	18–53
Elephantopus nudatus	21	50	77
Scleria triglomerata	14	50	—
EPIPHYTES			
Tillandsia usneoides	—	100	—
Polypodium polypodioides	—	62	—

* The data from the 17 stands is taken from Bourdeau and Oosting (1959).

Floristic Composition:

A total of 148 species was recorded in the eight stands. Of these 28 were trees, 29 shrubs, 14 woody vines, 5 herbaceous vines, 65 herbs, and 7 epiphytes. Those that are present in four or more

of the stands are listed in Table 2 with the frequency of their occurrence in the 70 10 x 10 meter quadrats.

The incipient and intermediate live oak hammocks on scrubby flatwoods areas have 15 species that are commonly found in the scrubby flatwoods or in the resulting young live oak hammocks. As the hammock matures, they begin to disappear. Fifteen species are restricted to the mature live oak hammock in scrubby flatwoods areas. Eighteen species are found only in the intermediate live oak hammocks on the sandhill site. Most of these are herbs that are characteristic of the previous longleaf pine-turkey oak community. Eighteen species are restricted to the coastal live oak hammocks.

Discussion

The ecology of live oak and live oak hammocks is too large a subject to be covered with the small amount of ecological information pertaining to this species and communities of which it often forms an important part. The discussion which follows is not an attempt to cover the ecology of live oak hammocks in detail.

Live oaks occur mainly in the coastal plain from Virginia through Georgia, throughout Florida, along the Gulf of Mexico into Texas and Oklahoma. Throughout this range the species is found on dry to wet sandy soils (Fernald 1950). Most of the literature dealing with live oak on the Atlantic coast reports studies of the maritime forests in North Carolina (Wells 1939, Wells and Shunk 1938, Bourdeau and Oosting 1959). The role of live oak in these maritime forests was probably first stated by Wells (*loc. cit.*). He noted the absence of the inland climax oak-hickory in the coastal live oak stands and this lead him to consider live oak as a salt spray climax. Does this mean that live oak forms a salt spray climax along the Atlantic and Gulf coasts, particularly in Florida?

To answer this question it will be necessary to describe briefly the coastal vegetation in northeastern Florida. Immediately inland from the Atlantic Ocean and windward of the foredunes exists an area, which for all practical purposes, is void of vegetation. The next zone inland is the foredune on which *Uniola paniculata* L. is the most characteristic sand binder, which in turn commonly gives way to a thicket type of vegetation on the back of the foredune. Usually the thicket is composed of saw palmetto, live oak, myrtle oak, redbay and Chapman's oak (see Kurz 1942). This thicket in

many ways resembles the scrub vegetation, which in Florida is associated with older shorelines (Laessle 1958b), extends inland where it may gradually merge into typical scrub vegetation and later into a live oak hammock or mesic hammock. The latter stages of this trend are illustrated in Figure 1.

Figure 2. Two clones of live oak, both many stemmed and exhibiting the dense, dwarf form so characteristic of the species just back of the dunes where fire has been frequent.

In the area between St. Augustine and Flagler Beach, Florida, the thicket, scrub-like vegetation (Fig. 2) may extend from the rear of the foredune, inland for approximately a half mile before it merges into the forest. This thicket is not only under the influence of salt spray but of frequent fire. It appears that the latter factor is at least as important in prohibiting the development of the live oak forest as is salt spray. During the present study, it was impossible to ascertain how close to the ocean the live oak forest can develop, however, it can be definitely stated that the forest can develop closer than its present location.

A careful examination of Figure 1 will show that species in the forest bordering the thicket, have begun to appear in the thicket as small trees. This suggests that the forest is encroaching onto the thicket vegetation. This leads to the following questions:

(1) How close to the ocean can the forest exist, and (2) how is the thicket converted to forest? The first question cannot be answered now and only a partial explanation of the latter is evident.

It has been proposed by many authors including Wells (*op. cit.*) that salt spray is important in vegetation zonation in coastal areas, however, other factors may at times be of considerable importance. In northeastern Florida fire appears to be one of these factors. Every stand investigated showed obvious signs of fire. Also, local inhabitants quickly point out that fires are frequent along the coast. The apparent role of fire in the present expression of coastal vegetation depends partially upon its frequency and intensity. The low thicket type vegetation composed of saw palmetto, live oak, myrtle oak, and Chapman's oak, when burned frequently, has a growth form expression quite similar to the fire pseudo-nanism (Fig. 2) reported in pitch pine (Andresen 1959). This low tangled mass of plants creates conditions which make it difficult for other species to invade. Even if more mesic forest species do invade, they are eliminated or kept in a dwarfed and subdominant condition by fire. As the frequency and intensity of fire decreases, the dwarfed live oak begins to increase in height forming a canopy over the other species and as a consequence the latter begin to become less important. After the formation of the live oak canopy, an intense fire may revert the area to thicket whereas less intense and frequent fires tend to maintain the live oak forest. The less frequent and intense fires which occur in the live oak forest are still adequate to prohibit the establishment of mesic hammock species. Whenever the live oak forest is unburned the mesic hammock species tend to become established. After they have been established, the fire susceptibility of the mesic hammock species decreases with age. After the mesic hammock has developed, fire may kill the above ground portion, but the species are maintained partially through root sprouts.

Sprout growth is clearly of two types. Both live oak and laurel oak send out "rhizomes"[2], often to distances 20 to 30 feet from the main trunk. Sprouts from these rhizomes are frequently present in mature stands but they appear to remain repressed indefinitely under such circumstances. Frequent fires also prevent any single

[2] These sprouts are probably not from rhizomes in the strict sense but develop from buds forming on roots as mentioned under *Quercus alba* forma *rependa* (Michx.) Trel. in Fernald (1950).

sprout from a clone from attaining dominance (Laessle 1958a). The other type of sprout growth which is exhibited by magnolia, redbay, hickory, and wild olive, is from the region approximately at the root crown or stem base. Young magnolias growing in dense shade, and of spindley habit, not infrequently are bent to the ground where they layer. The basal end of these layered trees sends up another sprout so that many apparently separate trees may in actuality be derived from a single seed.

In one of the stands studied along the coast, magnolia, laurel oak, and pignut hickory (climax mesic hammock species) were close enough to the ocean to exhibit the sheared crowns characteristic of woody plants under the influence of salt spray (Fig. 3). This is an indication that the inland mesic hammock climax species can exist under the effects of salt spray. Kurz (1942) also recorded magnolia as an important species in the coastal dunes.

Figure 3. A view of the mature live oak hammock on Silver Bluff dunes. The landward trend of the live oak branches is evident just to the right of center. Two magnolias, center, the larger of which shows toward its top a similar effect of wind and salt spray. This hammock lies on the first dune ridge in Section 28, T. 7 S., R. 30 E, of the St. Augustine Quadrangle.

Does this mean that the live oak in North Carolina does not form a salt spray climax? This study cannot prove or disprove the salt spray climax for the North Carolina maritime forest as pro-

posed by Wells (*op. cit.*). It may be that the inland deciduous oak-hickory climax of North Carolina cannot develop under the influence of salt spray. However, it is interesting to note that most of the climax species of northeastern Florida occur in the warmer coastal areas of North Carolina. It may be that such influence as fire, availability of seeds, and the factor of time have not permitted the broadleaved evergreen climax to reach its northern potential.

Certain soil and geological factors cannot be overlooked. The dune hammock is almost certainly of Silver Bluff age or approximately 5,000 years old. Its relationship to the more modern dunes on the east is similar to the situation discussed by MacNeill (1950), in which he describes the situation on Amelia Island in northeastern Florida as follows . . . "an inner ridge, built as a dune covered bar during Silver Bluff time, and a high outer dune-covered bar built by recent sea". The outer bar with its dunes is Bird Island, less than a half mile seaward from the dune hammock, but about three quarters of a mile from the open ocean (see the St. Augustine Quadrangle, U. S. Geol. Surv. 1943). The other two mature hammocks are situated on bars of Silver Bluff age but they are underlain by coquina deposited as submarine bars during Pamlico time. The underlying coquina no doubt contributes nutrients toward a more rapid growth toward climax vegetation, which once established, is quite resistant to regression back to live oak or scrub vegetation. The influence of the coquina, rich in calcium, is partially shown through the distribution of certain species which occurred along the transect. The calciphile yaupon did not occur in the last 20 meters of the scrub portion of the transect and cabbage palm did not occur in the last 50 meters of the transect, as the latter is particularly fire resistant, the soil pH is more important than fire in influencing the distribution of this species. East of the cabbage palm zone plants requiring acid conditions make their appearance, *Lyonia ferruginea* Nutt. in the last 80 meters, *Vaccinium caesium* Greene in the last 100 meters, *V. myrsinites* in the last 20 meters. The dwarf nature of the vegetation in the scrub region of the transect may be determined mainly by two factors: (1) the poorer nutrition of the acid soil causing its dwarf and denser nature and the much higher occurrence of saw palmetto, the dead fronds of which are highly flammable, enabling (2) fire to retard the vegetation more frequently and in a more drastic degree than in the hammock portion of the transect. Since the climax mesic hammock

species can apparently develop under the influence of salt spray, it appears that fundamentally the poverty of the soil and the occurrence of fire in the scrub zone are the primary factors in its maintenance.

Most of the inland live oak hammocks covered in this study were located on slightly higher portions of the pine flatwoods. The sequence of live oak hammocks from incipient, intermediate, to mature (Table 1) support the idea that drier portions of the flatwoods, when protected from fire, may pass through a live oak type of hammock before the climax mesic hammock develops. It is not the intent of the authors to convey the idea that all drier portions of the flatwoods pass through a live oak stage nor is it their intent to say that the mesic hammock terminates succession on all such sites. However, the general sequence appears to be scrubby flatwoods—live oak hammock—mesic hammock as interpreted by Laessle (1942). The speed of successional change in this sequence appears to be closely related to the severity and frequency of fire, to the availability of seeds and to soil fertility. The composition of the climax hammock will undoubtedly vary considerably due to the influence of these factors.

Summary

Wells (1939), working on Smith Island in North Carolina, referred to the live oak forest which fringes the coast as a salt spray climax—the inference being that the inland climax forest could not develop under the influence of salt spray along the coastal area. He, plus several other workers have later submitted more supporting evidence of the salt spray climax along the North Carolina coast.

In northeastern Florida live oak forests form a small but important and conspicuous vegetation type. Such forests may be found on inland as well as coastal sites. On the inland areas, live oak stands may be encountered on sandhill sites, on better drained pine flatwoods areas, scrub sites, and fringing lakes, streams, and sinkholes. Live oak, under these circumstances plus an occasional fire, coupled with the longevity of the species, may persist for an extended period of time. In the mature live oak stands studied, which had been free of fire for a number of years, young individuals of the climax mesic hammock species were abundant. It is evident

that the live oak stands on the inland and coastal areas of northeastern Florida represent an extended subclimax maintained through burning and longevity of the species. It is concluded that the inland climax species can exist under the influence of salt spray, and hence, the live oak forest is not a salt spray climax in Florida.

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